Fast and Reliable Sedimentation studies

How to quantify sediment kinetics, packing & redispersing?

Many industrial products are subject, over their lifetime, to a sedimentation phenomenon that has a significant impact on the end-use properties (sunscreen efficiency, paint coverage, drug dosage) and requires anticipating the physical stability during the formulation steps. Limiting the settling process of particles improve the shelf life of the product. Likewise, an easy redispersion warrant a perfect homogeneity of the sample before to use. This note shows how sedimentation can be studied to rapidly evaluate shelf life, quantify, and compare formulations. Additionally, to fully understand the mechanisms of sedimentation, we present detailed calculations that can be done using the Turbiscan technology.

DEFINITION: SEDIMENTATION

Sedimentation is a phenomenon that consist of solid particles settling at the bottom of the container over time. It is mainly observed in suspensions.

A suspension consists of a solid particle dispersed in a liquid phase. These systems are thermodynamically unstable and will destabilize until complete phase separation. The reason of the instability is the difference of density between the solid particle and the continuous phase which leads to the migration phenomenon, so called sedimentation.

The sedimentation process can be quantified by the settling velocity expressed by the Stokes law:

$$v = \frac{\Delta\rho_p \, g \, d^2}{18\eta}$$

v : particle settling velocity

g : acceleration of gravity

d: particle diameter (assuming spherical)

η: kinematic viscosity of the fluid

$\Delta\rho_p$: difference between mass density of the particle and the fluid

The analysis of the Stokes Law gives some insight on how to limit the sedimentation: increasing the continuous phase viscosity, reducing the density differences or by reducing the average particle size.

Another aspect of the sedimentation is that it can be reversible, and the reversibility depends on particle-particle interactions, cohesion energy, packing of the sediment… The energy required to redisperse the sediment can be low (manual shaking of vaccines or beverages) or high (mechanical stirring for paints or building materials) and thus redispersion efficiency should also be studied.

SEDIMENTATION: CONVENTIONAL TEST

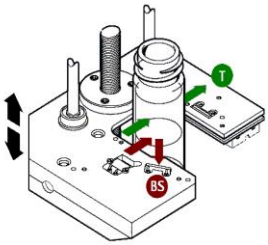
Easy to implement, visual observation remains the most used method for sedimentation testing, and thus stability analysis. The method is simple but can be time consuming as the variation must be visible to the naked eye to be detected. Additionally, the evaluation of the sedimentation kinetics is imprecise.

To overcome sedimentation issues, scientists need an **early identification** and **quantification** to apply the best strategy and measure the benefit of stabilizing agent addition.

TURBISCAN®: HOW IT WORKS

Turbiscan® technology, based on **Static Multiple Light Scattering (SMLS),** consists of sending light pulses (880 nm) into a sample along its height. The reading head scans the sample by moving vertically along the analysis cell and acquire data each 20 µm. Measurements are made over time and variation in the backscattering and transmission levels due to sample instability are recorded.

The signal is directly linked to the evolution of particle concentration (φ) and size (d) by the Mie theory.



$$BS = f\,(\varphi, d, np, nf)$$

Samples with a particle concentration from 10^{-4} to 95% (v/v) and from 10nm to 1mm in particle size can be measured as is.
The instrument enables to monitor changes in physical stability (coalescence, creaming, sedimentation, phase separation, etc...) **without any dilution or any stress** and thus follows ISO TR13097 guidelines.